



Canadian Psychiatric Association  
Association des psychiatres du Canada

# **Electroconvulsive Therapy Workshop**

## **ECT: Technique and Equipment**

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No disclosures to declare.



# The Art of ECT

- Ensure medical safety
- Minimize cognitive adverse effects
- Optimize symptom reduction



# Symptom recovery/ cognitive outcome determined by:

- electrode placement
- pulse parameters
- stimulus dose in relation to seizure threshold
- degree of cognitive impairment prior to ECT
- ECT frequency
- concurrent use of medications

# Electrode Placements in ECT

Bitemporal

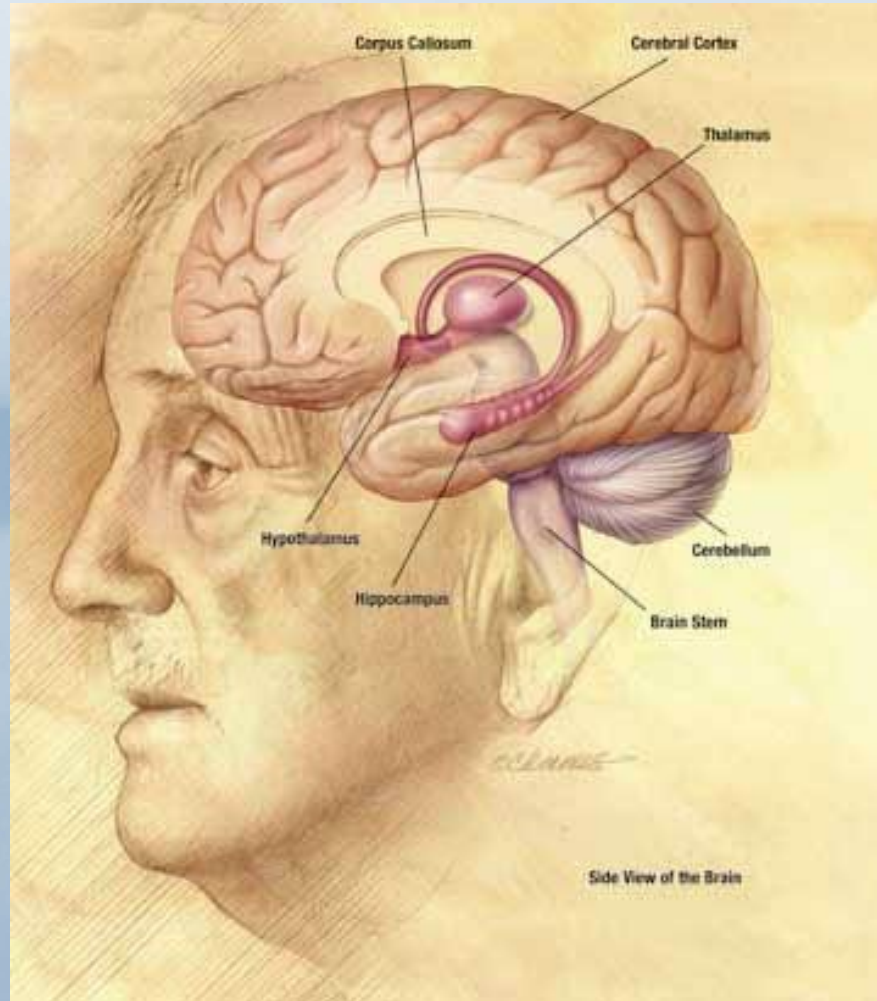
Right (or left) unilateral

Bifrontal





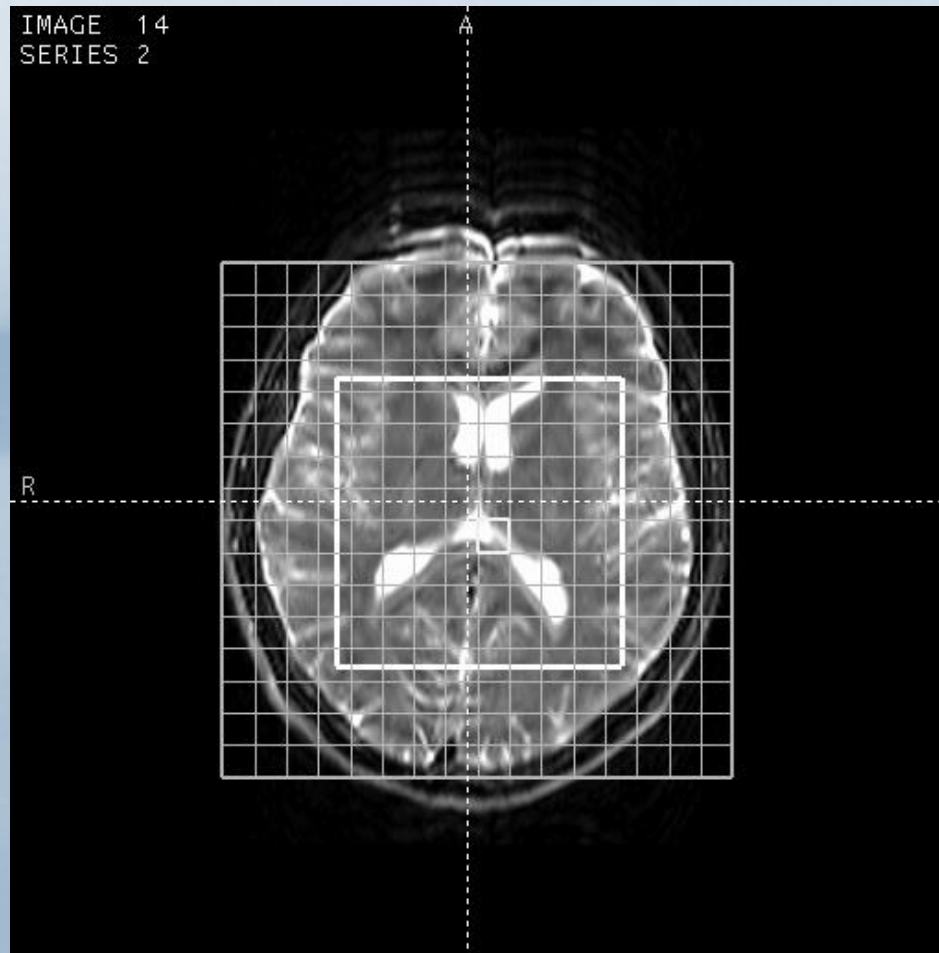
Clinical Application:  
Does where we place electrodes impact cognition and degree of benefit?



# Current Density

Weaver, Williams and Rush  
1975 Biological Psychiatry

Grid: 1154 1-cm<sup>3</sup> volumes; current density of each calculated



# Current Density in Bilateral and Unilateral ECT: Findings

## Unilateral Electrode Placement

- Current densities are greatest directly underneath the electrodes and
- In the areas of the brain in the cortex along the inter-electrode axis i.e. “the entire scalp region serves as a virtual electrode”

## Bilateral Electrode Placement

- *The bilateral placement induces a significantly higher current density in almost all areas of the brain than RUL*
- Current density is greatest directly underneath the electrodes and
- Current density is next greatest in the frontal lobes anterior to the inter-electrode axis



## The influence of electrode placement on electrical current:

Excitability of the brain varies:

i.e. the motor strip has the lowest intrinsic seizure threshold

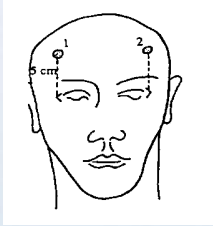
Theoretically → unilateral ECT should require a lower dose than bilateral ECT

*But.* Unilateral (UL) electrodes are closer together than bitemporal electrodes → increased shunting through the scalp results

i.e. a 1/3 decrease of overall current density is lost

D'Elia position = the preferred UL placement maximizes inter-electrode distance

1986 Mukherjee & Sackeim:



## Bifrontal Electrode Placement

1969 J. Inglis

1972 Abrams/Fink

Goal: Avoid hippocampal gyri

Abrams: electrodes 2" apart, daily ECT, sine wave device

Result:     - skin burns  
              - little benefit over UL

→ abandoned

# Bifrontal Electrodes

Letemendia 1993

5 cm. above outer corner of eye on a sagittal plane

Bailine 2000

Delva 2001

Heikman 2002

Sienart 2009

Kellner 2010 & 2010

Dunne 2012

Phutane 2013



# Left Unilateral ECT

1968-1970:

- 6 studies all conclude RUL>LUL

- Bad reputation results

- BUT:* Sinewave devices, non-d'Elia positions

1989: Abrams, R.

- 30 depressed Veterans

- Ham-D after ECT #3 & #6: excellent recovery

## ECT in Left-handed patients

- ~70% are left-hemisphere dominant for language
- ~15% are right-hemispheric dominant
- ~15% have bilateral hemispheric language representation

Bryden 1982

### Caution:

- “handedness” for writing may not be in keeping with hemispheric representation for language

ie: many left-handed people have been forced to write with their right hand

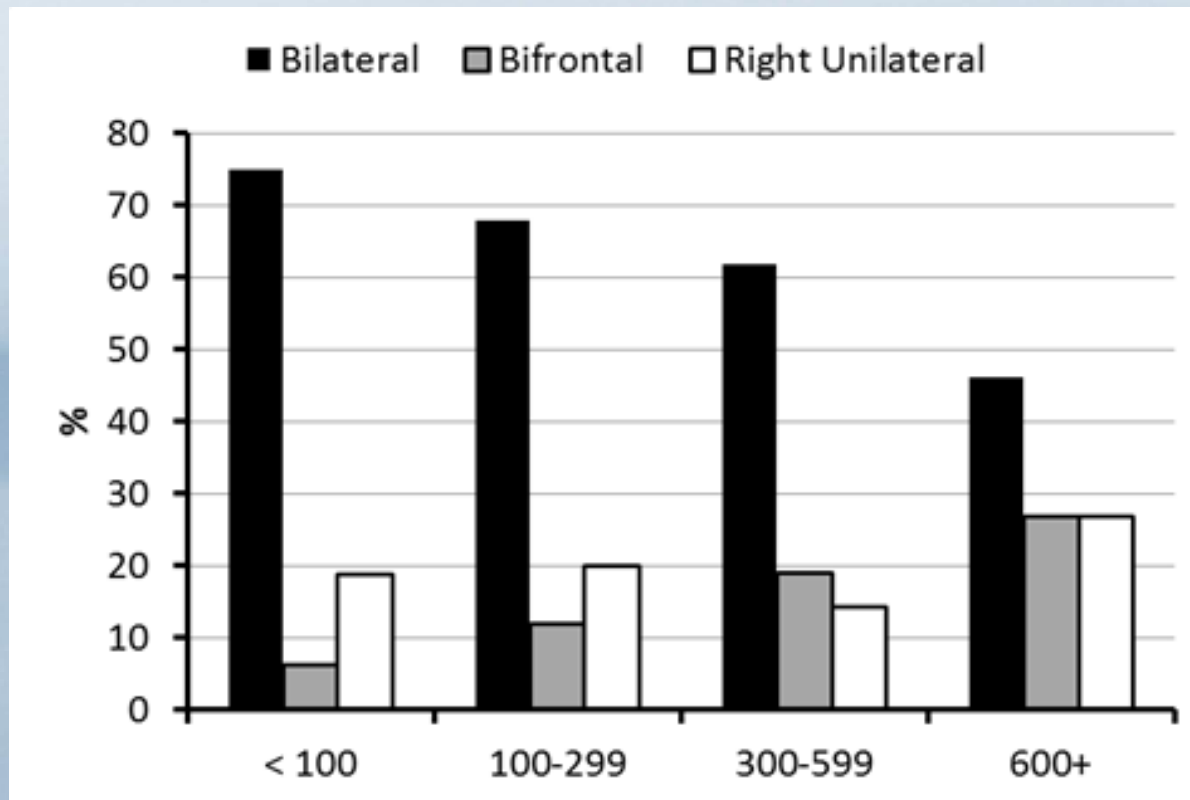
- Some “right handed” people are actually ambidextrous

Bottom line: Right unilateral ECT is usually administered, regardless of handedness



## CANECTS/ECANEC 2008

Preferred electrode placement according to number of treatments per year

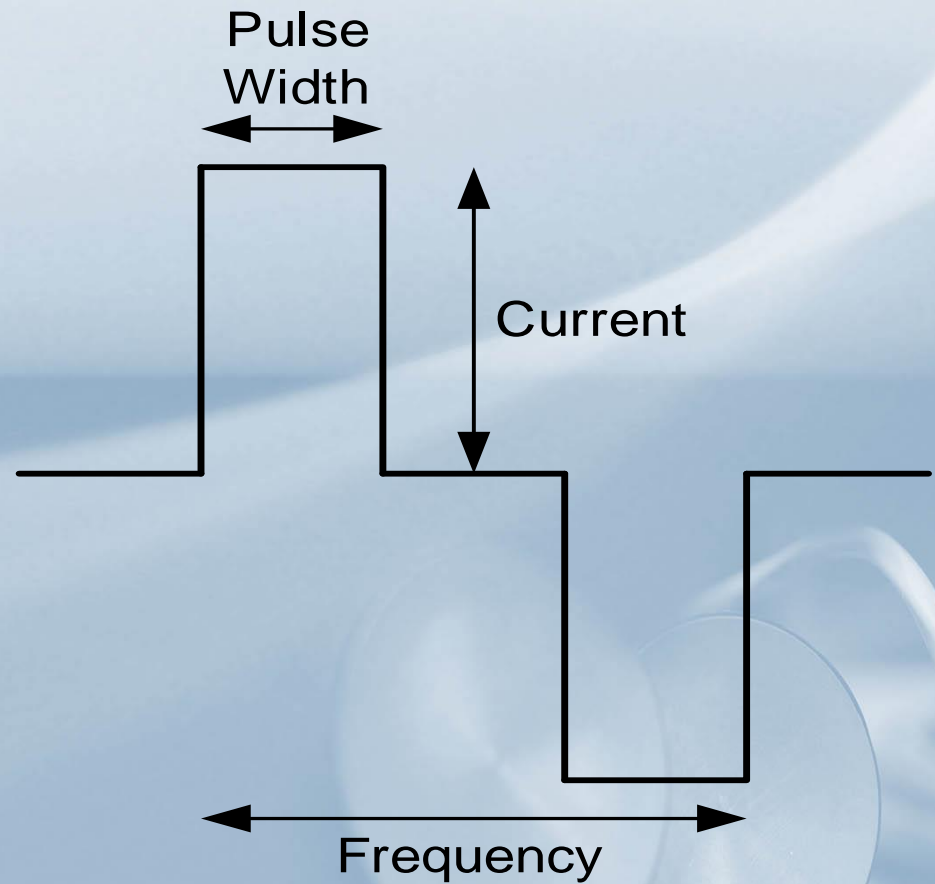


## Schools of Dosing Protocols

- Half age-based
- Fixed high dose RUL
- Titration Method

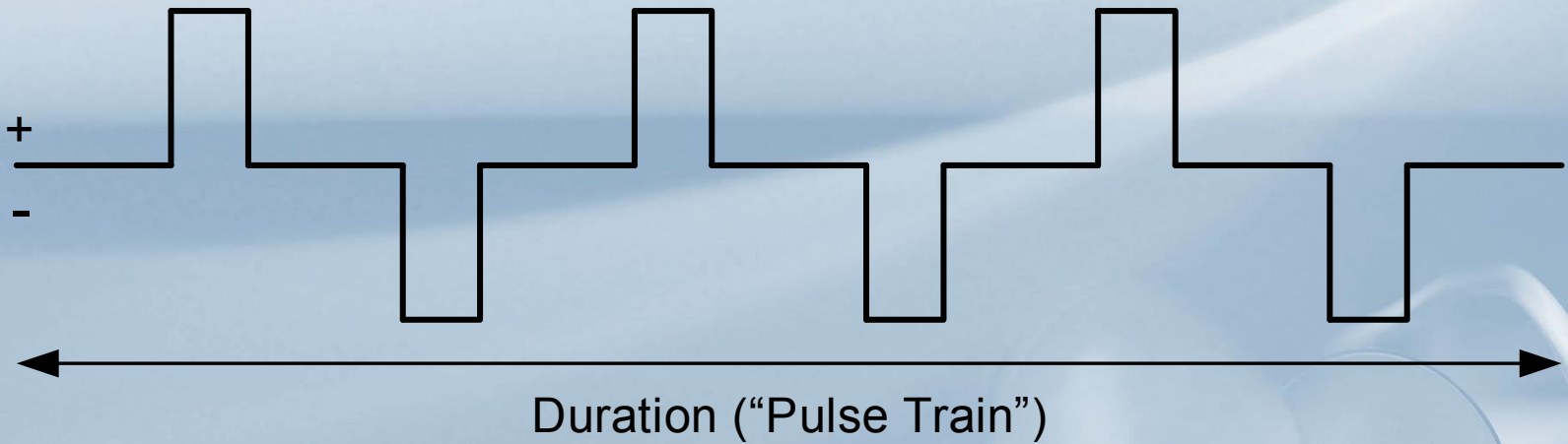
# Modern ECT Devices

Brief Pulse Device



## Modern ECT Devices

### Brief Pulse Device



## Brief Pulse Device

- Brief Pulse = 0.5-2 msec
- Ultra brief Pulse =  $<0.5$  msec
- Brief rectangular shaped pulses with an instantaneous rise and fall are a more efficient way of neuronal excitation than are sine waves and create dramatically less cognitive side effects



# Charge in ECT

- ECT treatment response depends on dosage
- By convention Total Charge mC – the amount of electricity - has been adopted as the “equivalent” of dose
- Charge has been used for decades as an outcome measure in ECT research but the appropriate equivalent of “mg” in ECT is in fact unknown.
- “Total Charge” obscures the ECT pulse parameters
- **An infinite number of pulse parameter combinations exist which all result in the same total Charge (see next slide)**

e.g. Much less Charge is required to induce a seizure with a pulse width of 0.3 msec than with a pulse width of 1.5 msec.

**Figure A: Total Charge = 3.2 mC PW 0.5 msec Frequency 100 pps amp 800mA pulses = 8**

**Figure B: Total Charge = 3.2 mC PW 8 msec Frequency 100 pps amp 50 mA pulses = 8**

Figure A

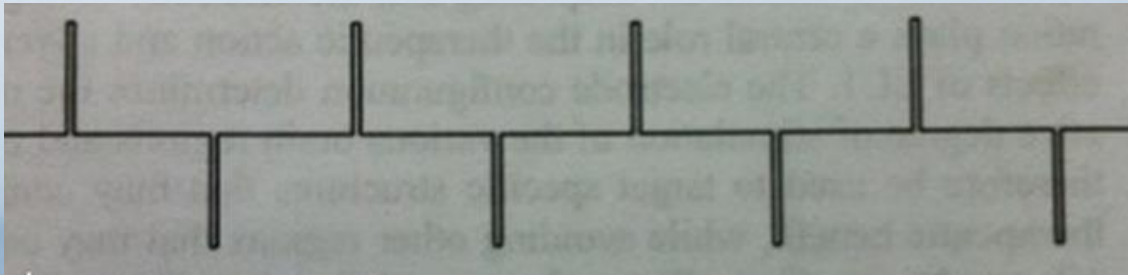
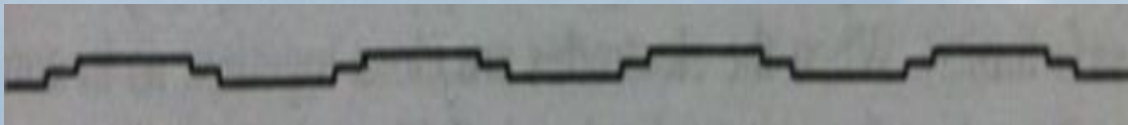


Figure B



# Effects of pulse parameters on ECT outcome

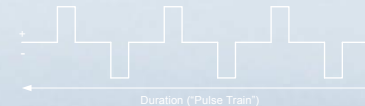
High ST is *amplified* by ECT pulse parameters which are inefficient at high doses

“This is an artefact of the titration schedule itself, rather than a true indication of biological differences between patients.”

Namely:

Titration schedules which drive up the frequency and the pw rather than the pulse trains iatrogenically raise seizure thresholds – which is *not* a reflection of a patient's own inherent ST

## Pulse Train (Duration)



Longer pulse trains require less Charge

### **Mounting evidence:**

shorter pw + lower amplitude + larger # of pulses results in the same benefit  
as pulses with

longer pw + higher amplitude + less # pulses

***but with less cognitive side effects***

# ECT Dosing Strategies (cont'd)

## The Half-Age Method

- Bilateral ECT
- Twice Weekly
- Starting dose = energy level of  $\frac{1}{2}$  patient's age

e.g. Age 60- start at 30% of the maximum output deliverable by the device.

- *Petrides, Fink 1996*



# ECT Dosing Strategies (Cont'd)

## Fixed High-Dose Right Unilateral

- All ECT at maximum capacity
- 0.25-0.5 ms pulse width
- 8 sec. pulse train

If no improvement, switch to Bilateral ECT

*Abrams 2002*

# ECT Dosing Strategies (Cont'd)

## Titration Method

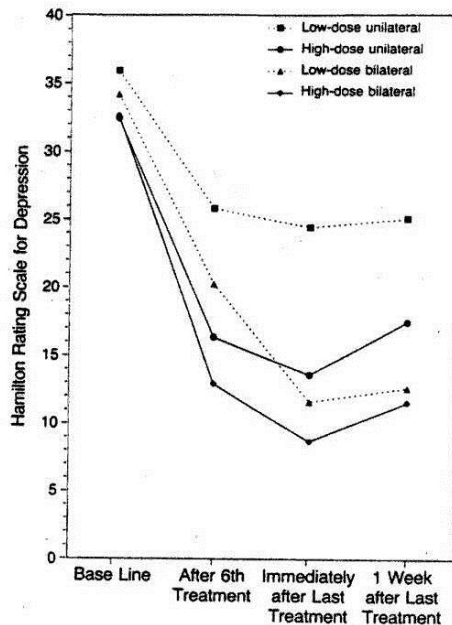


Figure 1. Mean Scores on the Hamilton Rating Scale for Depression at Base Line, after Six Treatments, Immediately after the Last Treatment, and One Week after the Last Treatment in the Four Groups.

## Response Rates

Low-dose RUL: 17%

High-dose RUL: 43%

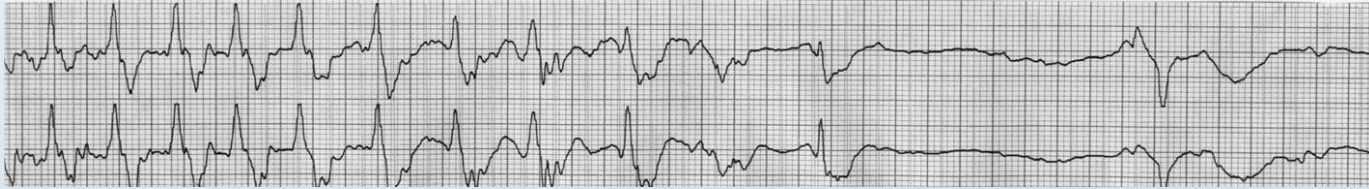
Low-dose BL: 65%

High-dose BL: 63%

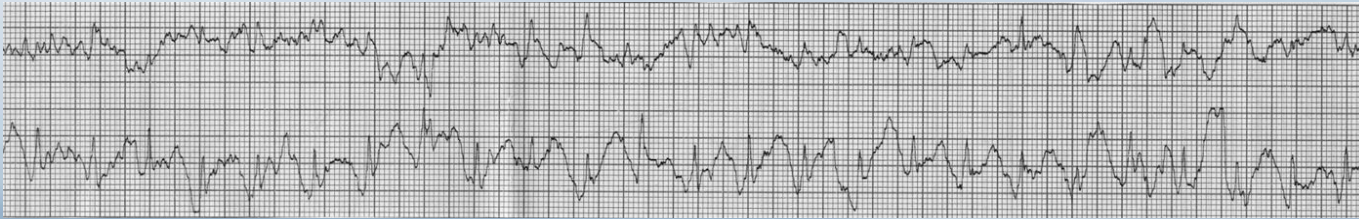
Sackeim, Prudic, Devanand et al. N Eng J Med  
328;12.1993

## Seizure Threshold in ECT

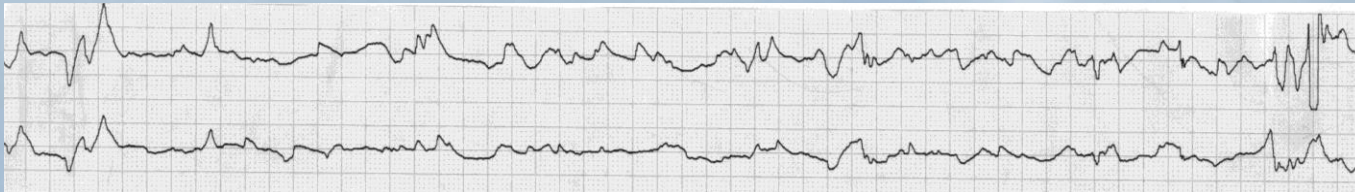
**B.**



**A.**



**Seizure threshold**



# ECT Dosing Strategies

## ➤ Titration Method

### ECT # 1: “Finding” Seizure Threshold

- Stimulate with a low electrical test dose (sub convulsive for majority of patients)
- If no seizure results, ***under the same anesthetic***, restimulate at a higher dose until a seizure is obtained - up to 4 stimuli: 3 is usual

*Sackeim, Decina, Kanzler, 1987*

## 1.5X seizure threshold dosing table

**Table 5-6.** Dose titration techniques for MECTA SpECTrum models (ultra-brief-pulse stimuli)

Dose level	MECTA SpECTrum 4000Q/5000Q					MECTA SpECTrum 4000M/5000M	
	PW (msec)	F (/sec)	D (sec)	I (amp)	Charge (mcoul)	Stimulus level <sup>a</sup> (%)	Charge (mcoul)
1 <sup>b</sup>	0.3	20	2.0	0.8	20	3	17
2 <sup>c</sup>	0.3	30	2.0	0.8	29	5	29
3 <sup>d</sup>	0.3	40	2.5	0.8	48	8	46
4	0.3	50	3.0	0.8	72	13	75
5	0.3	50	4.5	0.8	108	20	115
6	0.3	60	6.0	0.8	173	30	173
7	0.3	90	6.0	0.8	259	45	259
8	0.3	100	8.0	0.8	384	70	403
9	0.37	120	8.0	0.8	568	100	576

*Note.* amp = amperes; mcoul = millicoulombs; msec = milliseconds; sec = seconds; /sec = Hertz.

<sup>a</sup>Percent of maximum output charge.

<sup>b</sup>Start at dose level 1 for unilateral ECT in female patients.

<sup>c</sup>Start at dose level 2 for bilateral ECT in female patients or unilateral ECT in male patients.

<sup>d</sup>Start at dose level 3 for bilateral ECT in male patients.



## Titration Method (Cont'd)

ECT #2: if necessary continue to restimulate at higher doses until a seizure ensues

Various dosing protocols are available to select increasing doses from, to avoid the Gestalt method

*In general:*

For BF & BL ECT: increase by 1.5-2.0 X threshold

For UL ECT: increase by 2.5-6.0 X threshold

## Titration Method (Cont'd)

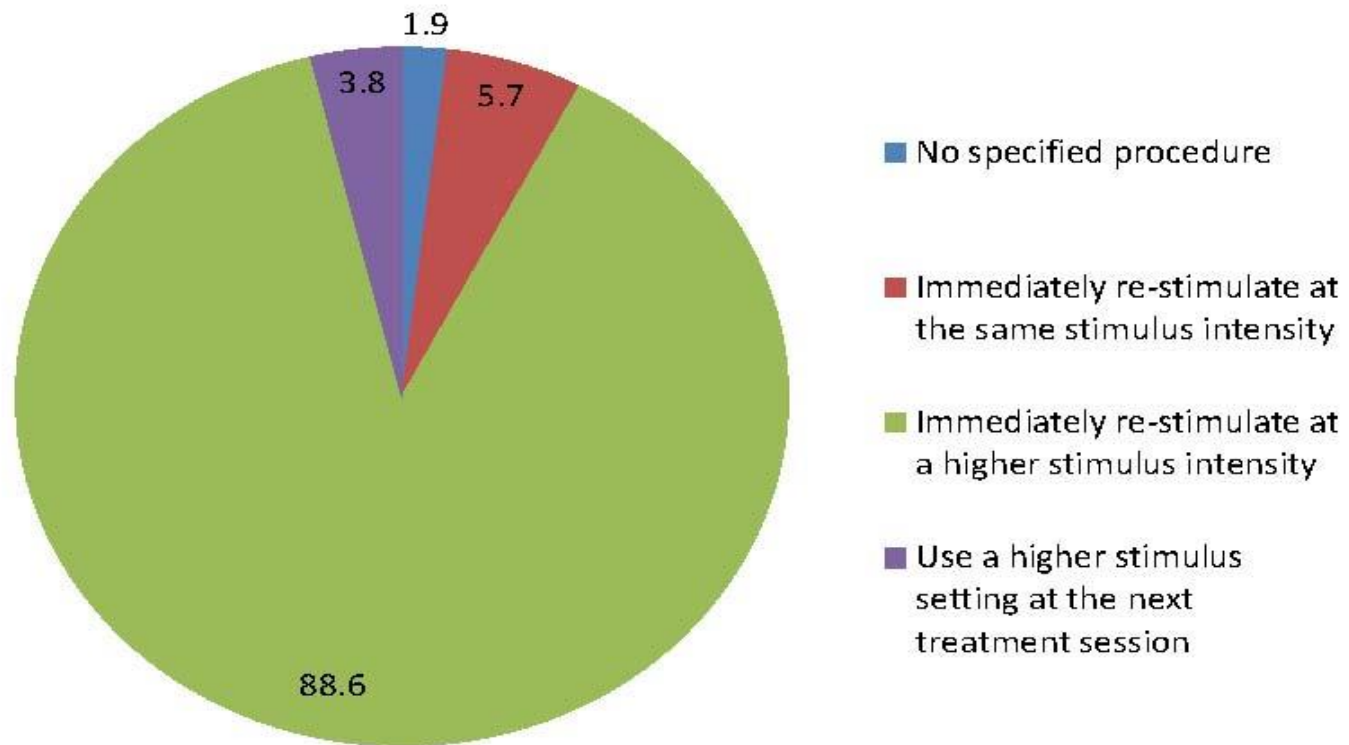
ECT #3 → Onwards

Maintain same dose, or gradually increase using:

1. EEG morphology AND
2. Clinical response

as a guide.

6.12 If the ECT electrical stimulus results in **no** seizure activity, what procedure is **usually** followed at your facility? (check one only)



## ECT “Adequacy”

A. Clinical response

B. EEG Morphology

1. High Amplitude
2. Presence of polyspike and slow wave activity  
= Delta Waves
3. Interhemispheric ictal coherence = “symmetry”
4. Sharp onset of and sustained post-ictal suppression

- ❖ Simply creating a seizure is not good enough
- ❖ Seizure length is not a measure of seizure adequacy

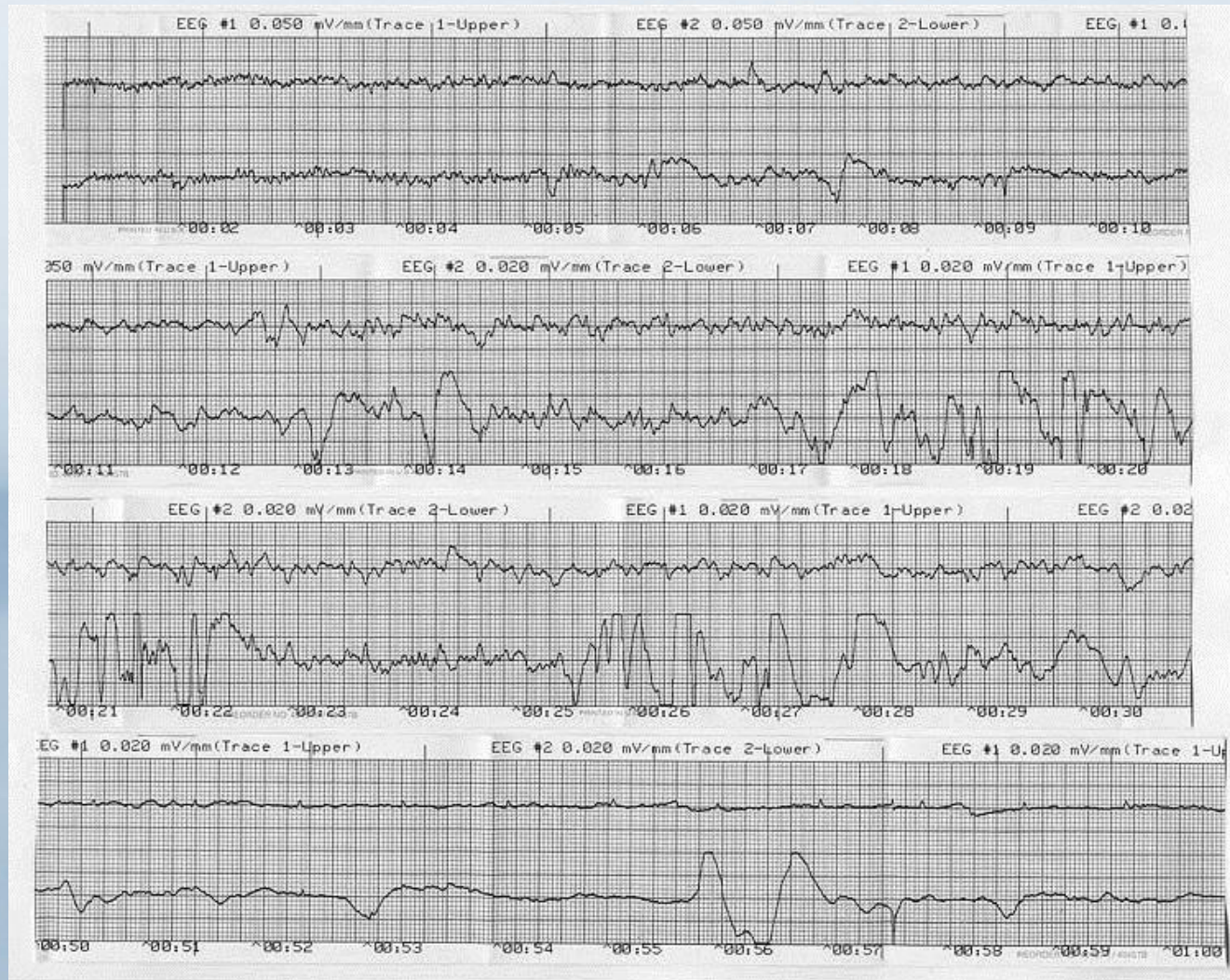


# EEG 1





# EEG 2



## Schools of Dosing Protocols: Concerns

- Titration: sub-threshold stimuli may bear risk (parasympathetic response)
- The Age-based and Fixed-high Dose methods:
  - seizure threshold (ST) varies from 36 to 869 mC (24-fold) yet
  - age accounts for only 17% of the variability (Boylan L) therefore

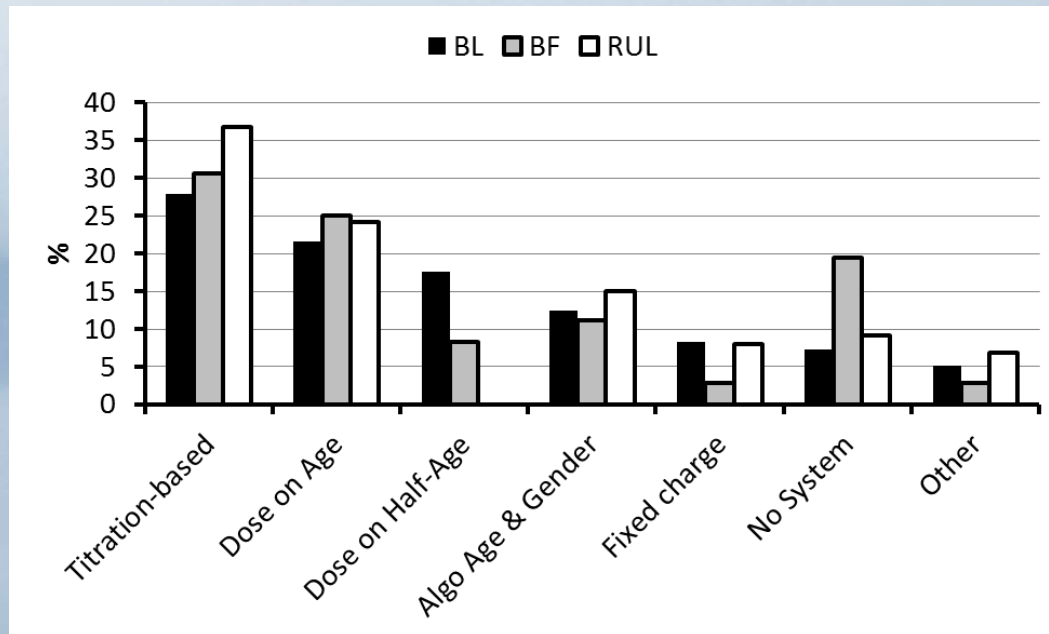
***risk of treating with unnecessarily high stimuli in patients with low ST and visa versa***

## General Agreement Exists:

- Patients respond faster to BT ECT than RUL ECT
- Patients who do not respond to RUL ECT may undergo a significant clinical improvement with BT ECT
- BT ECT results in greater cognitive SE than RUL ECT
- Relative stimulus intensity – but *not* absolute stimulus intensity is a significant predictor of response

Basis for choosing treatment intensity of the 1st stimulus for:

bilateral (BL)  
bifrontal (BF)  
right unilateral (RUL) electrode placements





## Missed or Aborted Seizures

### Possible Causes:

- excessive impedance from poor skin contact
- stimulating electrodes not screwed in firmly enough
- hypercarbia from inadequate ventilation
- hypoxia from inadequate ventilation
- dehydration
- medications (benzodiazepines, anticonvulsants)
- insufficient stimulus

## Missed or Aborted Seizures (cont'd)

correct above measures

missed:

- restimulate after 20 sec at a higher dose

aborted:

- restimulate after 45 sec at a higher dose to allow repolarization
- caffeine sodium benzoate 500-2000 mg. po 1 hour pre-ECT with 50cc H<sub>2</sub>O
- **flumazenil** 0.2 - 0.4 mg. I.V. (max. 1 mg.)
  - if high dose benzodiazepines
  - midazolam in P.A.R. to prevent withdrawal
  - **LIFE SAVING**

*Bailine 1994; Krystal 1998*



# Elements of ECT Technique

- ❖ Skin Preparation
- ❖ Mouth guard & non-conducting jaw support
- ❖ Rails down, footboards off
- ❖ Peripheral nerve stimulator +/-
- ❖ Pre-oxygenation
- ❖ Optimize electrode-to-scalp contact



Only 10 – 20% charge delivered by the ECT device  
enters the brain

**Impedance = resistivity + capacitance**

**Capacitance** = the property of being able to *accumulate charge*

**Resistivity:**

CSF:	65 ohms/cm	(Geddes & Baker, 1967)
scalp + brain:	220 ohms/cm	(Rush & Driscoll, 1968 and 1970)
<b>skull:</b>	17,760 ohms/cm	(Driscoll, 1970)

*Result:*

**80 – 95% current is resisted by the skull and shunted through the scalp**

# Monitoring Seizures

## EEG

### Ictal Motor Activity

#### ➤ Cuff Method

- Prior to succinylcholine, inflate cuff above ankle to 100 mm Hg above Systolic B.P.

#### ➤ Peripheral nerve stimulator

- Takes the guesswork out of finding the Point of Maximum Relaxation (PMR)  
Average: 90 seconds
- Essential for patients with
  - Osteoporosis
  - Slowed circulation time
  - Co-existent fractures (e.g. post-suicide attempt)